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Topic 2. Indoor environment

EFFECT OF STREAMER PLASMA AIR PURIFIER ON SBS SYMPTOMS AND PERFORMANCE OF OFFICE WORK

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ABSTRACT

Subjective experiments were conducted to evaluate the effect of a streamer plasma air purifier on perceived air quality, SBS symptoms and performance of office work during 5-hour exposure of 32 recruited subjects in field laboratory in which real materials were used to establishing a realistic level of air pollution. Intensity of SBS symptoms were indicated using visual-analogue scales. Subjects' performance was evaluated with several computer tasks. The results show that operation of the air purifiers improved perceived air quality and reduced the odor intensity of indoor air. Eye dryness symptom was found significantly improved when the air purifiers were used but no other SBS symptoms or performance of office work were improved when the air purifiers were in operation compared to the condition when they were off.

KEYWORDS

Air cleaning, Indoor air quality, Perceived air quality, SBS symptoms and productivity

INTRODUCTION

Due to the growing concern on building energy consumption and indoor air quality to ensure healthy and comfortable indoor environment, new technologies of indoor air purification have drawn broad attention. The air purification technology cleans the indoor air by removing contaminants from the re-circulated indoor air instead of ventilating the room with outdoor air. This approach saves the energy that is used to condition the ventilation airflow from outdoor conditions to indoor conditions. Efficient purification may lead to significant energy saving. There are many methods of air purification. As regard to the performance of each air purification technology, studies are needed to investigate their impact on perceived air quality, SBS symptoms and working performance under the long exposures. This paper presents a study that investigated the issue addressed above.

METHODS

The experiment was carried out in a field lab room with a volume of 113 m³ (6.0x5.9x3.2m), in which participants sat at eight workstations, each consisting of a table, a chair, a lamp and a personal computer (Fig. 1). The room air temperature, outdoor air supply rate and relative humidity in the test room were controlled at 22±0.5°C, 56±2 L/s and 40±5% RH respectively. Five air purifiers were installed in the test room.

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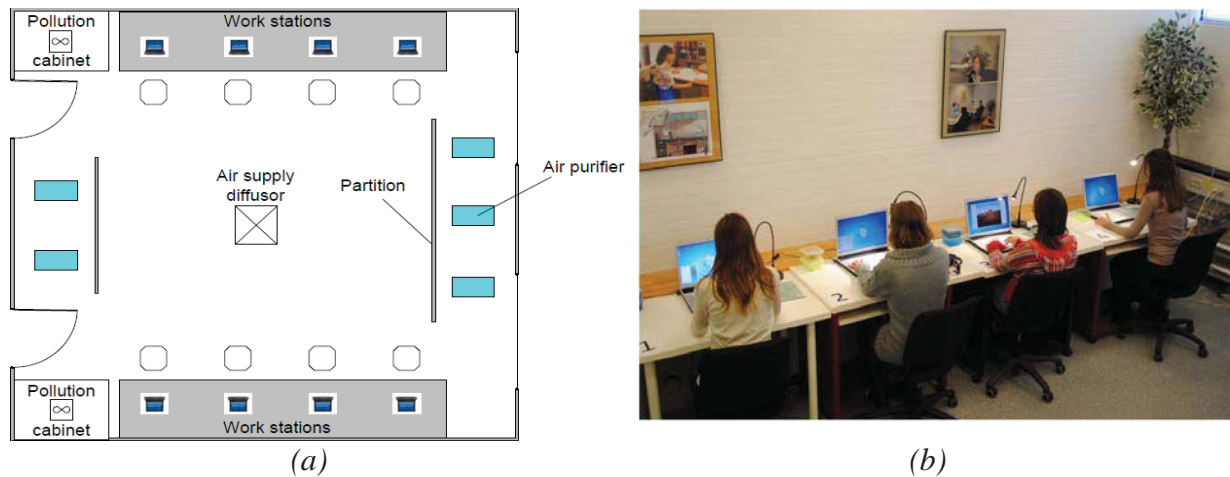


Figure1. (a) The layout of the experiment room, (b) a picture during the experiment

To establish a realistic level of air pollution in the test room, Carpet, chipboard and linoleum were used as pollution sources. They were hung on the trolleys which were placed inside the pollution cabinets and thus were invisible to subjects staying inside the room.

Thirty-two Caucasian students (16 females and 16 males) were recruited as volunteers for this experiment. They were equally divided into 4 groups (each composed of 4 males and 4 females) and participated in two five-hour experiments. Participants were required to wear suitable clothes to keep themselves thermal neutral through the whole experiment. The participants were paid at a fixed rate for their participation and all participants successfully completed experimental sessions.

During the five-hour exposure, the temperature, relative humidity, outdoor air supply rate, CO₂ and ozone concentration in the test room was monitored continuously. The subjects assessed perceived air quality and thermal sensation and reported the intensity of their SBS symptoms. Perceived air quality was assessed using acceptability and odor intensity scales (Wargocki 2005). Thermal sensation votes (TSV) were cast on the ASHRAE /ISO 7-point thermal sensation scale (ASHRAE 1997). The reported intensity of SBS symptoms were obtained from the subjects using standard visual-analogue scales (Wargocki, 1999). To evaluate the task performance, several computer tasks were given to the subjects: addition, multiplication and text typing. The performance was measured by calculating the speed at which the tasks were completed and the accuracy on completing the tasks. Subjects also filled in questionnaires examining their fatigue and motivation to work. Additionally to all the above measurements, physiological measurements were carried out (the results will be reported elsewhere). Differences among the experimental conditions were analyzed to study the impact of the air purifiers on perceived air quality and SBS symptoms. Nonparametric Wilcoxon test was used for the statistic analysis with the level of significance set at $p < 0.05$.

Two exposure conditions were established to evaluate the performance of air purifiers, Table 1. The experiment was run in two consecutive weeks from Monday to Thursday. The experimental design was in a balanced order of presentation for the two conditions among the four groups of subjects. The 5-hour experiments on each experimental day were carried out from 13:00 to 18:00. During the exposure in the test room, all the tasks and questionnaires were computer based; the subjects followed the computer program which guided them through the performance tasks and different questionnaires collecting subjective responses. The experimental procedure is illustrated in Figure 2.



Table1. The test conditions

| | Room <i>t</i> , RH and ventilation rate | Air purifier operation condition |
|-------------------------------|---|--|
| Condition 1 (Purifier on) | 22°C, 40%RH, 7L/s per person | Five air purifiers in operation Fan speed:"H" Air purifiers operated with all elements plus one additional catalyst attached at the outlet of each air purifier |
| Condition 2 (Purifier off) | 22°C, 40%RH, 7L/s per person | Five air purifiers in operation Fan speed:"M" Pre-filter, plasma ionizer, pleated filter, catalysts, streamer unit and humidifying wheel were removed from all the air purifiers |

| Task \ Time(min) | 0 | 15 | 17 | 32 | 35 | 38 | 48 | 58 | 68 | 78 | 118 | 120 | 125 | 135 | 137 | 147 | 157 | 167 | 177 | 217 | 219 | 224 | 228 | 230 | 240 | 250 | 260 | 270 | 272 | 277 | 280 | 295 |
|-----------------------|---|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Questionnaires | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Physiological Tests | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Simulated Office Work | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Neurobehavioral Tests | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tsai Partington | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Break | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Figure 2. Experimental procedure; the shadows indicate the corresponding task was performed during this period

RESULTS

Perceived air quality

Figure 3 shows the mean acceptability voting of the perceived air quality when the air purifiers were turned on and off. The acceptability of air quality was found systematically better when the purifier was turned on compared to the condition when it was off. The levels of acceptability of air quality upon entering the test room (without bio-effluents) corresponding to about 41% and 17% dissatisfied (visitors) and about 38% and 31% dissatisfied (visitors) upon reentering the test room (with bio-effluents) with purifier off and on respectively. Figure 4 shows the odor intensity assessed (as visitors) upon entering and re-entering the test room. There was modest though systematic and statistically significant reduction of odor intensity when the air purifiers were in operation, from about moderate intensity to slight moderate intensity. Figure 5 shows the time course of acceptability of air quality during exposure in the test room. It confirms that the air quality was assessed to be systematically better when the purifier was in operation and that the difference was statistically significant but quite modest. The acceptability of air quality improved along exposure independent of conditions, as expected, due to sensory fatigue (adaptation).

SBS symptoms

Figure 6 shows the eye dryness symptoms significantly improved during the exposure in the test room when the air purifiers were used. No systematic differences in intensity of SBS symptoms were observed in the conditions with purifiers on and off. Intensity of some symptoms increased along the course of exposure, as expected. For example subjects became more tired and it was more difficult to think clearly towards the end of exposure but these changes occurred independently of the conditions. Significant difference was only observed for the eye dryness symptoms.

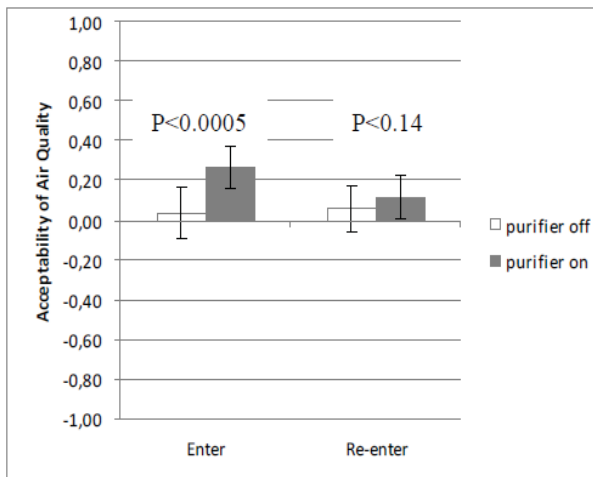


Figure 3. Acceptability of air quality assessed (as visitors) upon entering and re-entering the test room; -1= clearly not acceptable; 0= just not acceptable/just acceptable; +1= clearly acceptable; error bars show 95% confidence interval

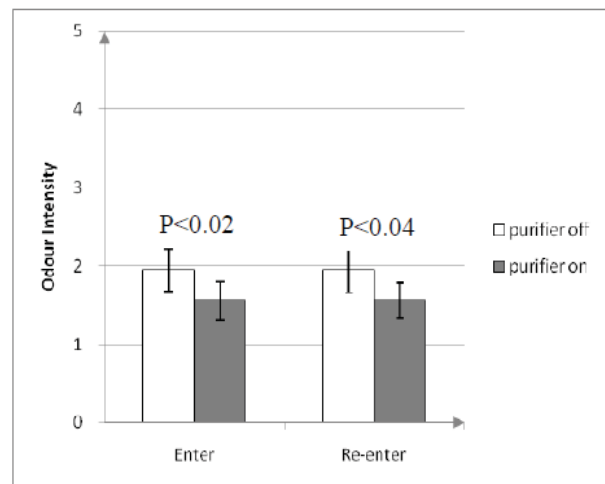


Figure 4. Odour intensity assessed (as visitors) upon entering and re-entering the test room; 0= no odour; 1= slight odour; 2= moderate odour; 3= strong odour; 4= very strong odour; error bars show 95% confidence interval

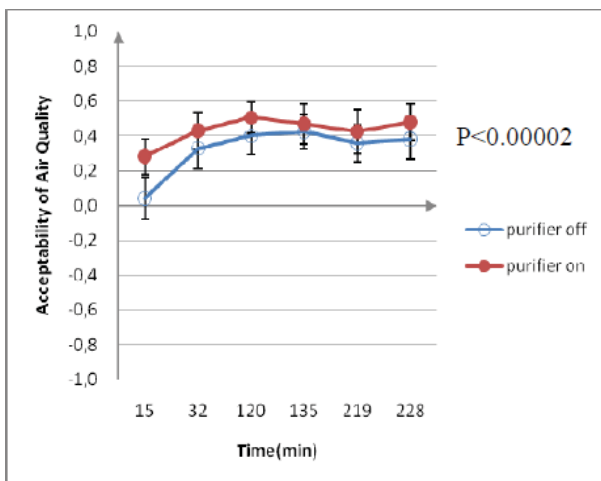


Figure 5. Acceptability of air quality as a function of time during exposure; -1= clearly not acceptable; 0= just not acceptable/just acceptable; +1= clearly acceptable; error bars show 95% confidence interval

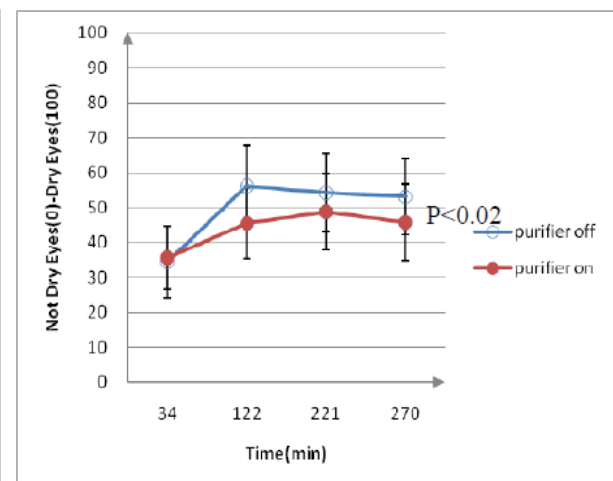


Figure 6. Intensity of SBS symptoms as a function of the time during exposure; error bars show 95% confidence interval

Evaluation of subjective symptoms of fatigue

To evaluate the feeling of fatigue, subjects completed the questionnaire suggested by the working group for occupational fatigue of the Japan Society for Occupational Health (Yoshitake, 1973). This evaluation method is used in the field of science of labour and ergonomics in Japan. It consists of three categories: Group I consists of 10 terms about “drowsiness and dullness”, Group II consists of 10 terms about “difficulty in concentration”, and Group III consists of 10 terms about “projection of physical disintegration”. Using the order of the rate of complaints among the three categories, three types of fatigue feeling are suggested: General pattern of fatigue: “I>III>II”, typical pattern of fatigue for mental work and overnight duty: “I>II>III”, and typical pattern of physical work: “III>I>II”. “General rate of complaints” are also defined as the rate of complaints of all thirty symptoms and is showed

in Figure 7. There were no systematic differences in the rate of complaints depending on the exposure.

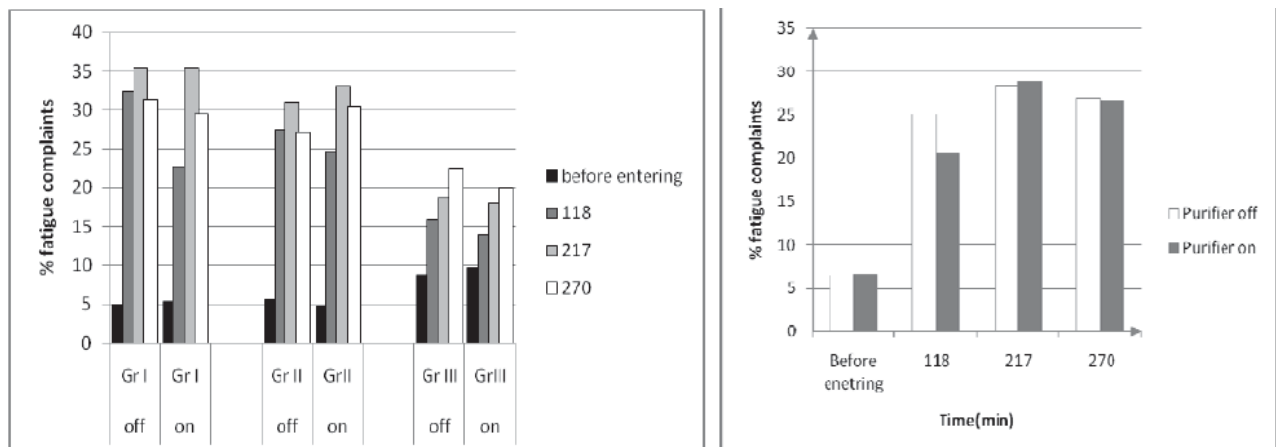


Figure 7. Fatigue symptoms reported by the subjects during exposure in the tests office separately for each of the 3 groups of fatigue symptoms as well as general rate of fatigue complaints

The Subjects felt slightly cooler when the purifiers were not operating. The results show no systematic difference between the performance of office work in the condition with purifiers on and off. The results of NASA-workload questionnaires show that there were no differences between exposures as to how mentally and physically demanding were the tasks performed either.

CONCLUSIONS

- 1) Operation of the air purifiers improved air quality in the test room.
- 2) Except for reducing eye dryness, there were no systematic changes in the intensity of SBS symptoms or performance of office work when the air purifiers were in operation compared with the condition when they were off.

It is important that the observed results showing the benefits of operating purifiers for the perceived air quality is also examined in longer exposures so that it can additionally be checked whether operation of air purifiers can provide other benefits by reducing health symptoms and improving the performance of office work. The present results do not preclude the use of these purifiers in actual applications in buildings as there were no results that could indicate negative effects. It seems reasonable to assume that when the efficiency of air purifier is further improved and/or the noise generated by the air purifier is reduced, the benefits will be apparent.

ACKNOWLEDGEMENTS

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